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Clarkson University
Potsdam, NY 13699

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13. ABSTRACT *(Maximum 200 words)*

By use of the ARO equipment grant and the Clarkson matching fund, the existing one channel Aerometric Phase Doppler Particle Analyzer is upgraded to a two channel system with a Fourier Spectral Analyzer. The prices of the components of the system are listed in Appendix A. This system is integrated into a complete system for the experimental investigation of intermittent sprays. The complete system is depicted in Fig. 1 in Appendix B. The system is used to measure the distributions of velocity and size of droplets formed in stationary as well as intermittent sprays of Diesel fuel and other test liquids. Preliminary results of the measurement are given.

14. SUBJECT TERMS
Phase Dopler Particle Analyzer, Atomization, Fuel Sprays, Jet

15. NUMBER OF PAGES
8

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17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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28829.1-EG-EP

MECHANISM OF ATOMIZATION AND BEHAVIOR OF NON-DILUTE SPRAYS

FINAL REPORT

S.P. Lin

June 1992

U.S. ARMY RESEARCH OFFICE

DAAL03-91-G-0078

CLARKSON UNIVERSITY

THE VIEW, OPTIONS, AND/OR FINDINGS CONTAINED IN THIS REPORT ARE THOSE OF THE AUTHOR(S) AND SHOULD NOT BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION, POLICY, OR DECISION, UNLESS SO DESIGNATED BY OTHER DOCUMENTATION.

FORWARD

The project 28829-EG-EQ "Mechanism of Atomization and Behavior of Non-dilute Sprays," was under the directorship of Dr. David Mann of the Division of Engineering and Environmental Sciences of the Army Research Office. The period of this project is from 15 March 1991 to 14 March 1992. The grant number of this project is DAAL03-91-G-0078. This project complements another project "Mechanism of Intermittent Atomization," DAAL03-89-K-0179 which is also under the directorship of Dr. David Mann. The writer is the principal investigator of both of the above mentioned projects.

1. Problem Statement

The fundamental mechanism of intermittent psrays such as that encountered in Diesel engines are investigated. A novel theory of intermittent sprays is developed. A complete development of the theory requires an accompanying experimental verification. The equipment grant is used to establish an experimental system for this purpose.

2. Summary of Research Results

The general layout of the constructed experimental system is show in Fig. 1 in Appendix B. This system is used to obtain some preliminary results which characterize the intermittent sprays of various duration in certain range of relevant flow parameters. Fig. 2 in Appendix B gives some typical results. The distributions of droplet size and velocity for an intermittent spray created by a pressure pulsation of 35 ms duration are given in the figure. The statistics of the droplets are taken at a point 0.25 in off the spray axis and 4 in downstream from the spray nozzle. More comprehensive results will be obtained. The results will be compared with theories to elucidate the fundamental mechanism of intermittent sprays. Fundamental knowledge is essential for rational design of fuel injection systems.

3. Participating Personnel

The following individuals have participated in the project.

a. Dr. S.P. Lin, Professor, Principal Investigator

b. Mr. D.R. Woods, Completed M.S. degree. Ph.D. Candidate, Research Assistant

c. Mr. V. Cook, Research Assistant, M.S. Candidate

d. Mr. Richard Webb, Research Assistant, M.S. Candidate

e. Dr. Z.W. Zhou, Research Associate

4. Bibliographies

Relevant bibliographies are cited in references of the published papers.

5. Publications

a. "A Branching Liquid Jet," S.P. Lin and D.R. Woods, Physics of Fluids A 3, 241-244, 1991.

b. "Mechanism of Spray Formation from Liquid Sheets," B. Creighton and S.P. Lin, Atomization and Sprays, 1, 187-198, 1991.

c. "Absolute and Convective Instability of a Compressible Jet," Z.W. Zhou and S.P. Lin, Physics of Fluids A, 4, 277-282, 1992.

d. "Nonlinear Instability of a Liquid Jet," E.A. Ibrahim and S.P. Lin, Journal of Applied Mech. (in press).

e. "Effects of Compressibility on the Atomization of Liquid Jets," Z.W. Zhou and S.P. Lin, AIAA J. Power and Propulsion (in press).

AEROMETRICS
Quotation Agreement

HEADQUARTERS
Aerometrics, Incorporated
Del Rey Avenue, Unit A
Sunnyvale, California 94086
Phone: (408) 738-6688
Fax: (408) 738-6871

REGIONAL OFFICE
Aerometrics, Incorporated
10500 Richmond Avenue, Suite 201
Houston, Texas 77042
Phone: (713) 266-3779
Fax: (713) 952-0289

APPENDIX A

TO: Dr. S.P. Lin
Clarkson University
Department of Mechanical Engineering
8 Clarkson Avenue
Potsdam, New York 13676

QUOTE VALID FOR 60 DAYS
Quotation Number: 92-1007
Date of Quotation: January 15, 1992
Freight Terms: FOB Sunnyvale
Payment Terms: Net 30 Days

WE ARE PLEASED TO QUOTE ON THE FOLLOWING:

ITEM	QUANTITY	DESCRIPTION	PRICE
		Two Component Phase Doppler Particle Analyzer CONSISTING OF:	
1	1	XMT 1240 Transmitter 2 Dimensional Transmitter, 40 MHz, 200, 500 & 1000mm focal length lenses	
2	1	RCV 2200 Receiver 2 Dimensional LDV Receiver, 500mm lens.	
3	1	DSA 3220-P Doppler Signal Analyzer 2 Dimensional FFT-based PDPA signal processor, 100 MHz maximum Doppler frequency peak detection capability, low pass filter choices at mixer outputs, variable oscillator frequencies & Fourier transform burst detector.	
4	1	SFT 5200-P/DSA System Software System Software for the Doppler Signal Analyzer, includes: instrument setup & control, Data acquisition, analysis and management. Optional external data inputs and reverse system control	
5	1	DMS 4128 Data Management System 486/33 computer: 64K cache, 200 MB Hard Drive, 8 MB RAM, 1.2 MB & 1.44 MB Floppy, VGA Adapter, SONY 1304 Color Display, 101 Key Keyboard, Mouse, DOS, printer.	
6	1	543 300A 300mW Argon Ion Laser & Power Supply Air-cooled laser, 300mW all lines, 12 month warranty.	
		Subtotal 1	$150.994
7	1	LENS 238mm F 2.4 Receiver lens Triplet	$ 3.980
		Subtotal 2	$153.974
		Credit for trade-in of PDPA system	$ 49.000
		Total	$ 104.974

Thank You

January 15, 1992

CLARKSON UNIVERSITY

Box 5560, Potsdam, NY 13699-5560

Telephone: (315) 268-7724 Fax: (315) 268-2310

No. 69584

This number must appear on all invoices, packages, packing slips and bills of lading.

DATE 2/26/92

TO
TRACY FOULER
AEROMETRICS
550 DEL REY AVENUE
UNIT A
SUNNYVALE CA 94086

5-26-92

SHIP TO
CLARKSON UNIVERSITY
RECEIVING DEPARTMENT – Box 5550
8 CLARKSON AVENUE
POTSDAM, NY 13699-5550
(315) 268-6543
(Delivery Inquiries Only)

DATE NEEDED 3/11/92

SEND 2 COPIES OF INVOICE TO: ACCOUNTS PAYABLE Box 5547 Clarkson University Potsdam NY 13699-5547 Fax: (315) 268-7994

F.O.B. POINT

THE TERMS & CONDITIONS AS STATED ON THE REVERSE HEREOF ARE APPLICABLE TO THIS PURCHASE ORDER

ITEM	DESCRIPTION	QUANTITY	UNIT COST	EXTENDED TOTALS
1	Two Component Phase Doppler Particle Analyser	1	150,794.	$150,794.
2	238mm F2.4 Receiver lens Triplet	1	3,180.	3,180.
	Trade-in PDPA System	1		-49,000.
			TOTAL	$104,974.

Delivery in person

Furnish Certificate of Insurance as described by attached statement to Office of Risk Management, Box 5563, Clarkson University, Potsdam, New York 13699-5563

FAXED 2-26-92

CLARKSON UNIVERSITY IS EXEMPT FROM PAYMENT OF NEW YORK SALES TAX, CERTIFICATE EX 108065

IF DELIVERY CAN NOT BE MADE BY DATE NEEDED, ADVISE SHIPPING DATE.

CLARKSON UNIVERSITY

C.P.:

PURCHASING AGENT

FOR PURCHASING DEPARTMENT USE ONLY

NAME	BUILDING		TITLE CODE	ACCOUNT NUMBER (S)	AMOUNT
S.P. Lin	Old Main			395-760-325	$72,824.00
				331-281-325	$16,075.00
DEPARTMENT MAE/Engineering/CAMP	ROOM NO 306	PHONE NO 6584	01	397-100-325	$16,075.00

Proposed System

APPENDIX B

Figure 1

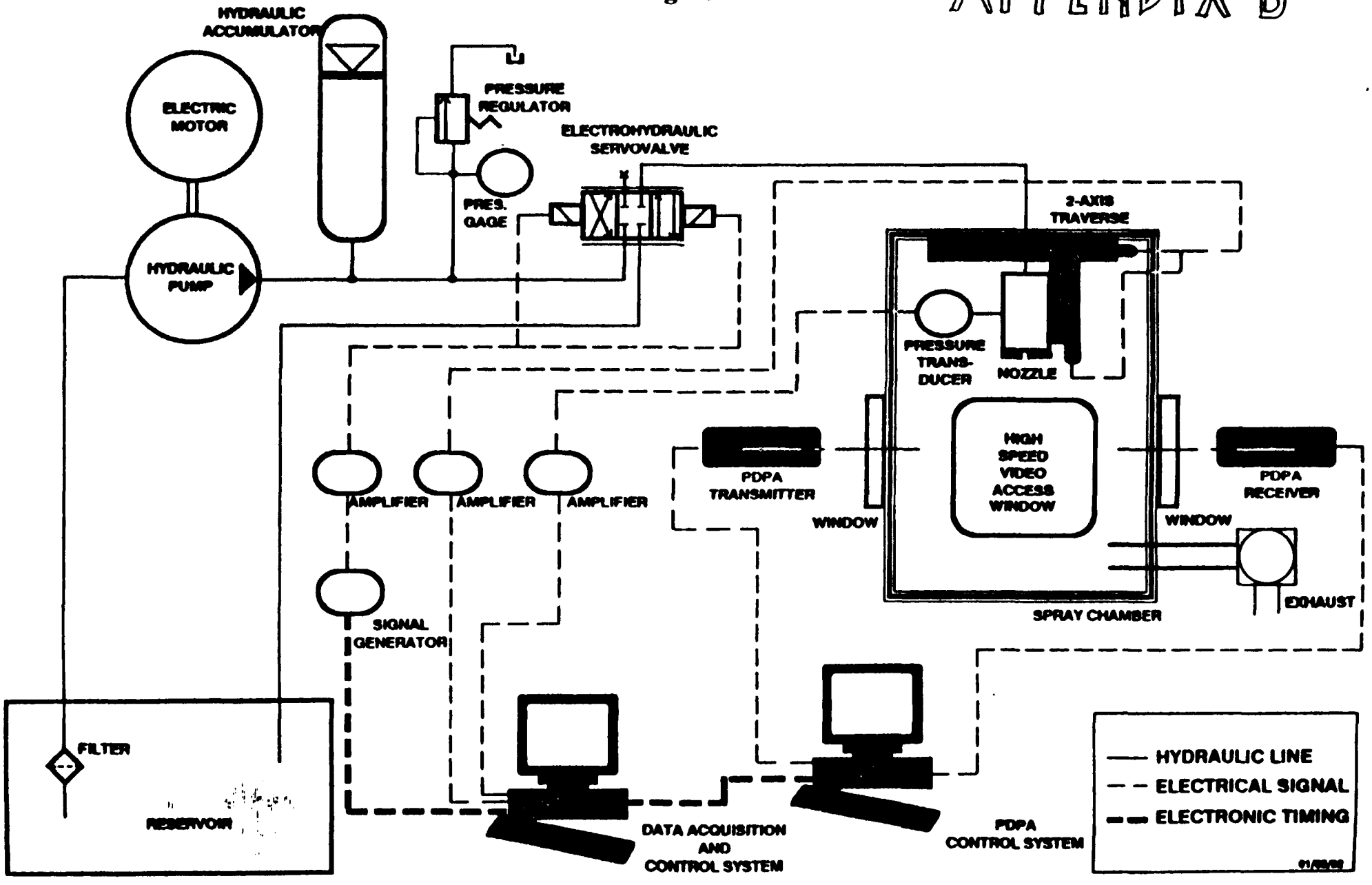


FIG. 2-a

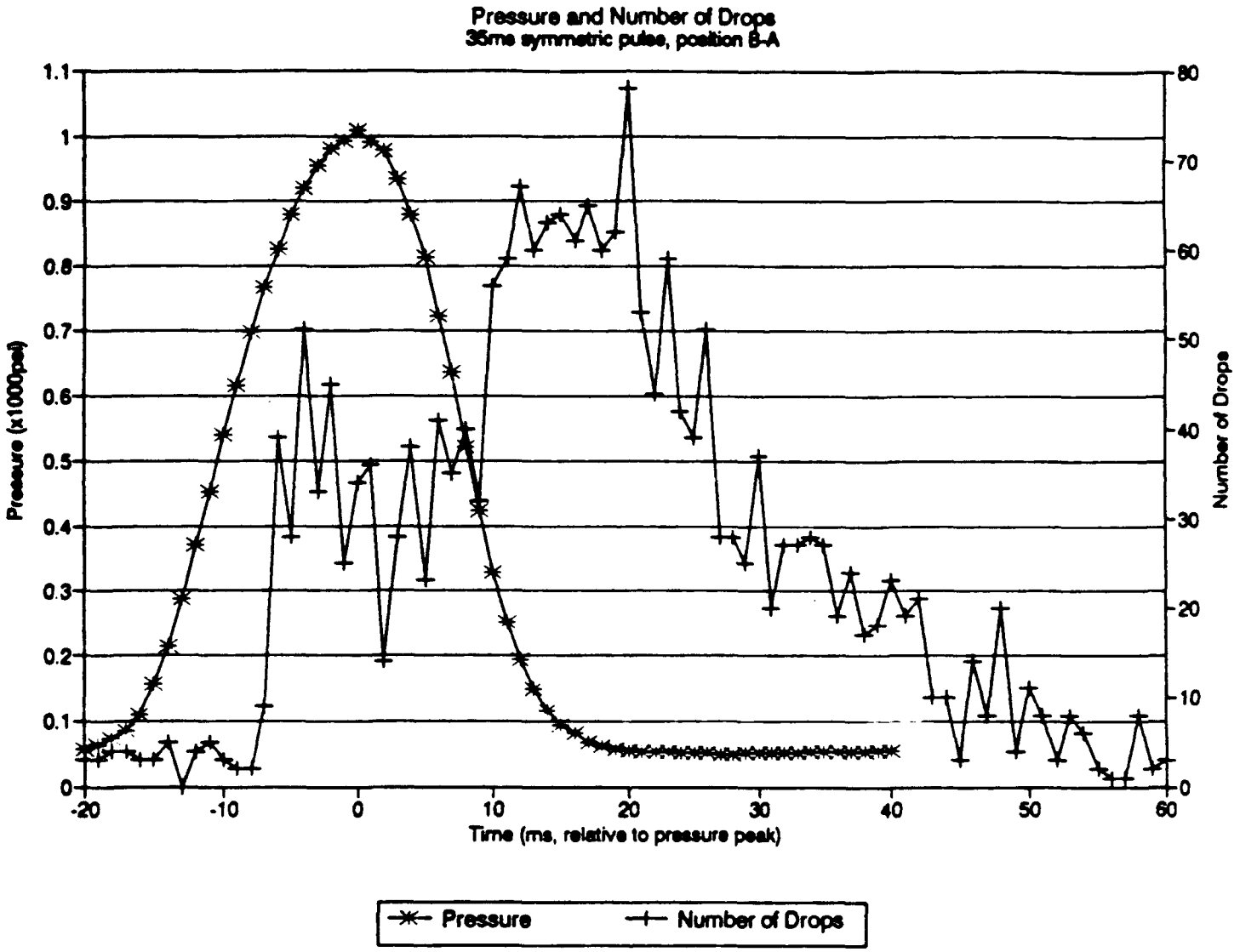
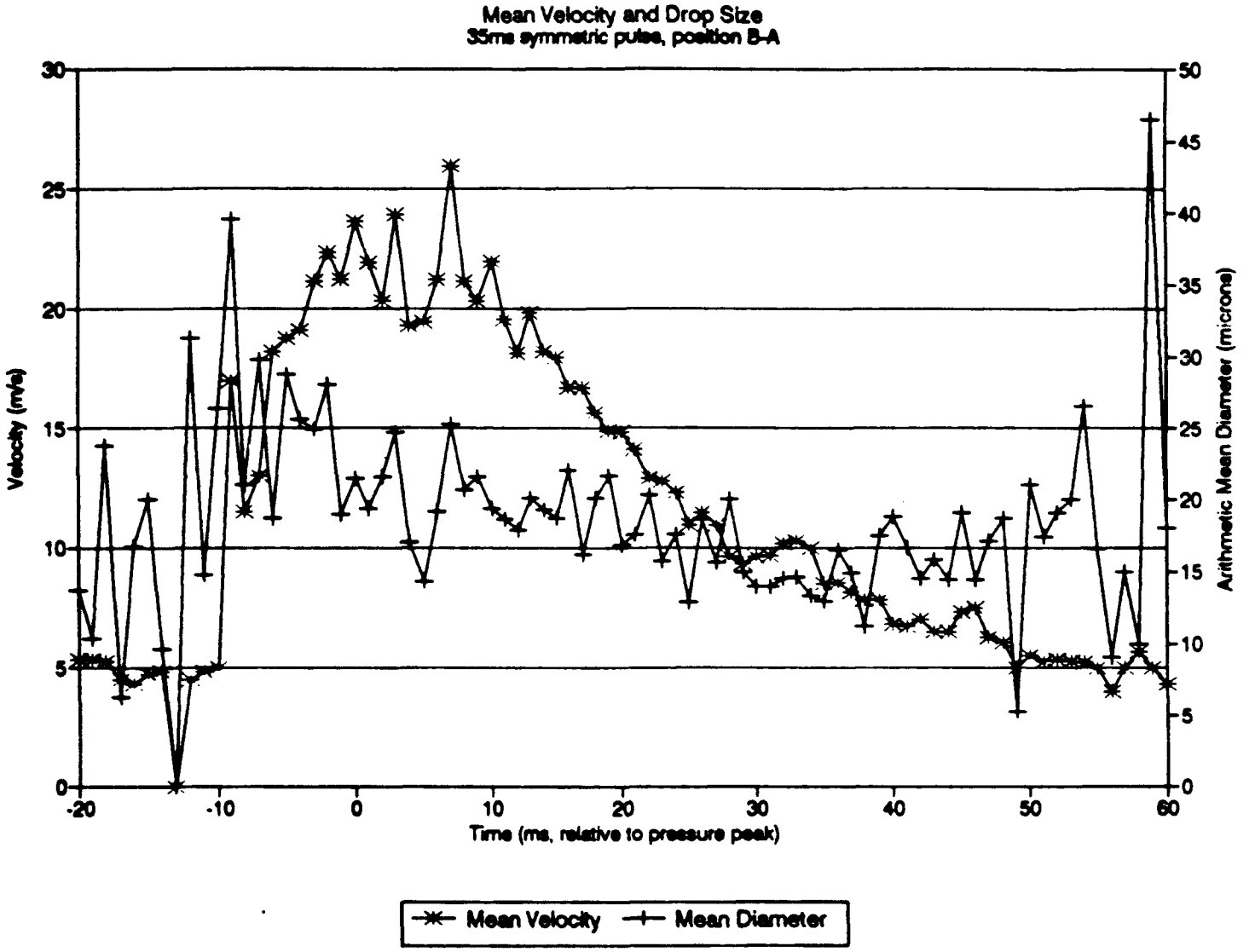

Pressure and Number of Drops
35ms symmetric pulse, position B-A
Pressure (x1000psi)
Number of Drops
Time (ms, relative to pressure peak)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
80
70
60
50
40
30
20
10
0
-20
-10
0
10
20
30
40
50
60
Pressure
Number of Drops

FIG. 2.- b


Mean Velocity and Drop Size
35ms symmetric pulse, position B-A
Velocity (m/s)
Arithmetic Mean Diameter (microns)
Time (ms, relative to pressure peak)
Mean Velocity
Mean Diameter